J. Entomol. Res. Soc., 17(2): 01-09, 2015 *ISSN:1302-0250*

Activity of Burying Beetles (Coleoptera: *Nicrophorus*) in the Forest Edge a Preliminary Study

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ABSTRACT

Burying beetles use small carcasses for reproduction. One of the most important factors reducing the negative impact of interspecific competition among them is habitat preferences. Their preferences were studied by several authors, but data about their activity in forest edge are insufficient. This preliminary study about relation between *Nicrophorus* species in the forest edge was conducted near the city of Poznań (western Poland). During observation significant differences between burying beetles activity were recorded. Furthermore, analysis of obtained data definitely showed that *Nicrophorus vespilloides* Herbst, a typical forest species, was frequently observed also in the forest edge. However, activity of *N. vespilloides* was shaped differently in different habitats. In the other hand typical meadow species, *Nicrophorus vespillo* L., was reported predominantly in cages placed in preferred habitat. These results could be explained by results of analysis of temperature data. Similar frequency of *N. vespilloides* in forest and forest edge might by related with similar temperature conditions observed in these habitats.

Key words: Burying beetles, *Nicrophorus*, habitat preferences, edge effect.

INTRODUCTION

Burying beetles use for reproduction carcasses of small animals (Kocarek, 2001; Scott, 1998; Steiger *et al.,* 2011). Due to intensive competition for resources, these beetles develop numerous mechanisms that reduce the negative impact of competitors. Parental care provided by both males and females distinguish these beetles from other necrophagous insects (Ratcliffe, 1996). Immediately after carcasses are found, burying beetles bury and prepare the resources. During this action, fur or feathers are removed from the carcasses. In addition, the resources are formed into a ball and preserved by anal and oral secretions (Arce *et al.,* 2012; Degenkolb *et al.,* 2011; Jacques *et al.,* 2009; Vogel *et al.,* 2011).

Except parental care, for burying beetles equally important mechanisms which also reduce competition are seasonal and diurnal activity, habitat preferences and carcass size preferences (Scott, 1998). However, a large number of researches concerning these aspects of burying beetles ecology were conducted in 80s and 90s of the twentieth century. Nevertheless, Trumbo *et al.* (2000) showed that one of main factor which influence on structure of burying beetles species is habitat fragmentation. This is

related with reduction of available area and possibilities for dispersion (Saunders *et al.,* 1991) and also creation of more edge habitats (Malcolm, 1994). Due to increasing of human activity this problem become important. For these reasons the aim of presented research is analysis of burying beetles activity in the forest edge.

At the edge of two types of habitat, changes in biotic and abiotic conditions are observed, which affect relationships between species (Heliola *et al.,* 2001). Very often species from both adjacent habitats are recorded in edge, but some species seem to be edge specialists (Didham, 1997). However, due to many variables, the intensity and direction of edge effect on population size differs between species, and even between different populations of the same species (Baker *et al.,* 2002; Duraes *et al.,* 2005).

Research conducted by Nisimura *et al.* (2005) and Wilson *et al.* (1984) suggested that main factor which may influence of burying beetles is temperature. Theoretically, species which prefer forest habitat have lower minimal temperature required to fly than typical meadow species. For this reason, we expected that during our research, depend on mean temperature, fluctuation of meadow and forest species activity in the forest edge will be observed.

MATERIALS AND METHODS

Insects

In the study area we observed two common species of burying beetles: *Nicrophorus vespilloides* Herbst and *Nicrophorus vespillo* L.. *Nicrophorus vespilloides* mostly was observed in forest habitats, which were dominant there. However, at the end of seasonal activity, this species was also frequent in open habitats. It was active from May to October. Individuals of this species were characterized by diurnal activity (Kocarek, 2001). *Nicrophorus vespillo* beetles are active between April and October, but the largest number of individuals was noted in early spring (Kocarek, 2001; Kocarek *et al.,* 1997). Beetles of this species were observed only in open habitats and were active from noon to midnight, but their activity peaked in the afternoon (Kocarek, 2001).

Study area

The study was conducted in outskirt of Suchy Las and the city of Poznań (N 52°28'38.92", E 16°53'56.71"). The area consists of patches of meadow and coniferous forest. The meadow are dry and warm plant communities characterized by southern exposure and low humidity and the most common plant species there are: *Achillea millefolium* L.*, Hypericum perforatum* L.*, Rumex acetosella* L. and *Berteroa incana* L. In addition, the presence of *Helichrysum arenarium* L.*, Convolvulus arvensis* L.*, Silene vulgaris* (Moench) and *Campanula, Viola* and *Viccia* species were noted. In forest habitats the most frequent is *Pinus sylvestris* L. Other woody plants present in this habitat are: *Betula pubescens* Ehr, *Sorbus aucuparia* L. and *Crataegus* species. The most common species in the undergrowth is *Impatiens parviflora* DC. The main component of the forest edge is *Prunus spinosa* L.

Burying beetles observations

The observations were conducted from 11 May 2011 to 17 September 2011, during nine research sessions. We used six cages, made of PVC pipes (height 30 cm, diameter 20 cm) and metal net (2 cm mesh). Cages construction prevented the access of larger scavengers, but did not limit the access of necrophagous insects. The cages were placed on transects, which included three habitats: meadow, forest edge and coniferous forest. Distance between cages was 50 m. To better imitate natural conditions, the cages were partly buried one month before the experiment was started. In the experiment we used carcasses of mice *Mus musculus* L., 35 g each. All of carcasses came from feeding culture and were unfreeze for eight hours before research session. Altogether we used 24 mice. Each research session lasted 4 days. On the first day of each research session, single carcasses were placed in the cages at 8 am. Daily monitoring, every 2 h, was started at 10 am and ended at 8 pm. In July and August, additional observations were conducted at 9 pm. During all the observations, we recorded numbers of individuals of each *Nicrophorus* species, and the beetles were left in cages. When the carcasses were buried, the soil was delicately checked for the presence of burying beetles. At the same time, air temperature was measured near the ground, in the randomly selected cages.

Data analysis

Statistical analysis of data, were made with STATISTICA software (version 7) and Microsoft Office 2010. Determination of changes in burying beetles activity in different type of habitat based on number of observed individuals. Furthermore, the data have been used also in analysis of day of carcass colonization and daily activity of burying beetles. These data were statistical analysed with Pearson chi-square test. For better recognition of observed changes, the data were also analyzed separately for each observed burying beetles species.

The normality of distribution of temperature data was analysed with the Shapiro-Wilk test. In order to check the homogeneity of variance, the Brown-Forsyth test and Levene test were used. For statistical comparison of temperature between habitats, we used one-way ANOVA, Tukey post hoc test and Mann-Whitney *U* test.

RESULTS

During observation differences between activity of *N. vespilloides* and *N. vespillo* were observed (χ^2=27.930, P<0,001). Burying beetles were active during almost all research series. However, in second part of September we did not reported any individuals and for this reason data on last research series were omitted from the analysis. The highest activity of former species was noted during first weeks of July. In the other hand activity of *N. vespillo* persisted at similar level during all research series (Fig. 1). Differences are also observed in number of trapping individuals in different habitats (χ^2=63.549, P<0,001). Individuals of *N. vespilloides* were observed more frequently in the forest and in the forest edge. Moreover, this species in the forest

edge was equally abundant as in the forest. *N. vespillo* usually was recorded in the meadow, but twice individuals of this species were observed in the forest edge (Fig. 2).

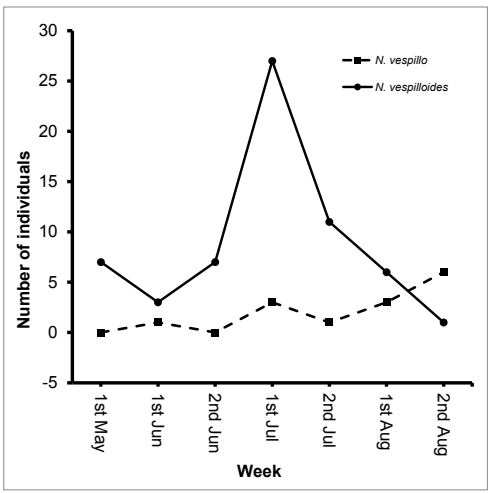

Fig. 1. Activity of *Nicrophorus vespilloides and Nicrophorus vespillo* during observation. Research series conducted in first and second week of each month are termed as first part of month; research series conducted in third and fourth week of each month are defined as second part of month. 1st May first part of May, 1st and 2nd June first and second part of June, 1st and 2nd July first and second part of July, 1st and 2nd August first and second part of August. Values are number of observed individuals.

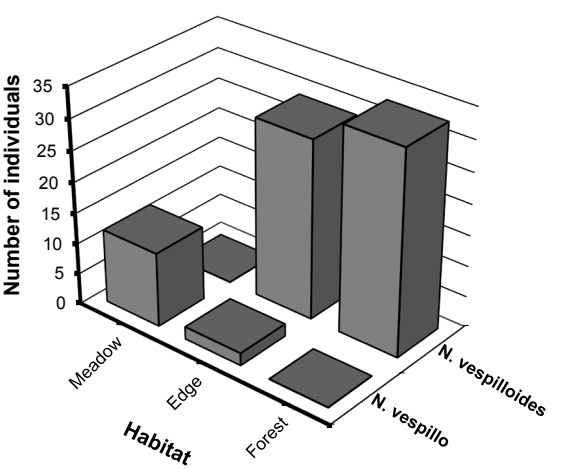

Fig. 2. Distribution of *Nicrophorus vespilloides and Nicrophorus vespillo* activity in three different types of habitat. Values are number of observed individuals.

Separate analysis for each of species showed differences in activity distribution of burying beetles in different habitats. In case of *N. vespilloides*, activity in forest was similar to overall results for this species. However, activity in forest edge was shaped differently (χ^2=22.405, P=0.033). Number of *N. vespilloides* observed in this habitat,

during almost all research series, remained at similar level (Fig. 3). In the other hand individuals of *N. vespillo* were activity in meadow and forest edge in different time (χ^2=14.000, P=0.030) (Fig. 4).

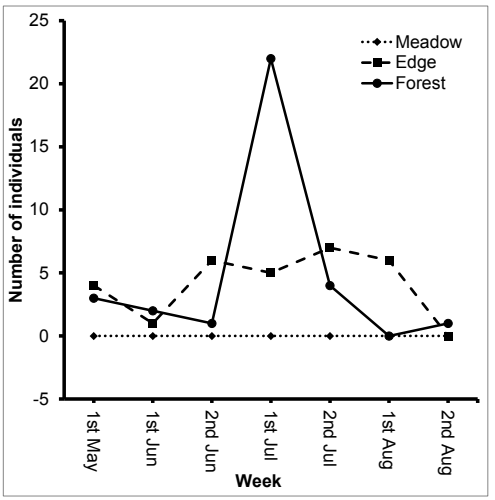

Fig. 3. Activity of *Nicrophorus vespilloides* in three different types of habitat during all research series. Research series conducted in first and second week of each month are termed as first part of month; research series conducted in third and fourth week of each month are defined as second part of month. 1st May- first part of May, 1st and 2nd June first and second part of June, 1st and 2nd July first and second part of July, 1st and 2nd August first and second part of August. Values are number of observed individuals.

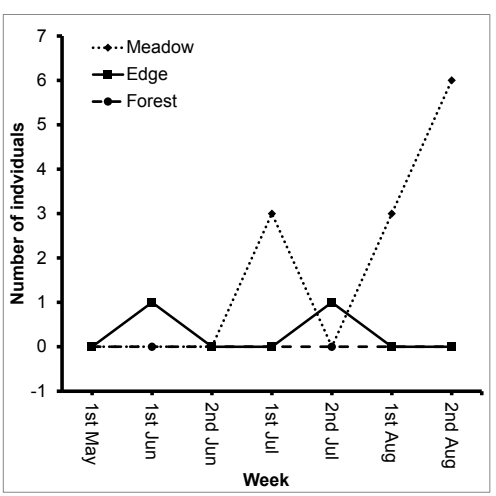

Fig. 4. Activity of *Nicrophorus vespillo* in meadow, forest edge and forest during observation. Research series conducted in first and second week of each month are termed as first part of month; research series conducted in third and fourth week of each month are defined as second part of month. 1st May-first part of May, 1st and 2nd June first and second part of June, 1st and 2nd July first and second part of July, 1st and 2nd August first and second part of August. Values are number of observed individuals.

Significant differences between species also in day of carcasses colonization were observed (χ^2=16.403, P<0.001). *Nicrophorus vespilloides* were recorded in all days of carcasses exposition, but the highest activity was noted in second day of research series. Separate results for forest and forest edge were similar to overall activity of *N. vespilloides* (χ^2=7.362, P=0.289). However, we recorded significant differences in day of carcass colonization in different month (χ^2=28.146, P<0.001). In June and July individuals of *N. vespilloides* usually found carcasses in second day of research series, but in May the level of activity was similar in each of day of carcasses exposition. In case of *N. vespillo*, number of observation gradually increased and the highest activity were observed during last day of research series. Similar trend were observed in meadow and forest edge (χ^2=0.636, P=0.425) and also in different months (χ^2=9.545, P=0.389).

N. vespilloides was active throughout the day, but the highest activity was observed at 8 pm. No significant difference in *N. vespilloides* daily activity between forest and the edge was recorded (χ^2=1.904, P=0.999). Also in case of *N. vespillo* we observed similar to *N. vespilloides* results. Despite this, results of presented research show that their activity peaked at 6 pm. No significant differences in daily activity between meadow and the forest edge were noted (χ^2=7.467, P=0.280).

Significant variation in temperature between the habitats was observed (F=6.416, P<0.001). There were significant differences between meadow and the forest edge (Z=6.512, P<0.001) and between meadow and forest (Z=7.136, P<0.001). Noteworthy is the fact that no significant difference in temperature conditions between forest and the edge was recorded (Z=0.992, P=0.320). Furthermore, peak of mean temperature did not overlap with burying beetles activity.

DISCUSSION AND CONCLUSION

The results of the presented research show that *N. vespilloides* was more frequent in carcasses placed on the forest edge than *N. vespillo*. The presented results are very similar to the results obtained in research about edge effect on dung and ground beetle distribution, as in ecotone and forest a similar species composition was observed (Heliola *et al.,* 2001; Yu *et al.,* 2006). Furthermore, in research conducted in the natural ecotone zone between tropical forest and corrado not only similar species composition between these habitats were observed, but also similar abundance was recorded. This result suggested that for some insect communities, edge effects play a less important role than habitat type in which the species exist (Duraes *et al.,* 2005). That hypothesis also supported our results, because between forest and forest edge, in which similar frequencies of *N. vespilloides* were observed, we did not record significant differences between temperature conditions.

One of the most important factors affecting competition between burying beetle species seems to be temperature (Trumbo, 1990a). A high impact of temperature on interspecific competition was observed inter alia between *Nicrophorus orbicollis* Say and *Nicrophorus defodiens* Mannerheim (Wilson *et al.,* 1984). In warmer conditions,

individuals of *N. orbicollis* usurped carcasses occupied earlier by *N. defodiens* and won the competition. By contrast, at colder temperatures *N. orbicollis* did not displace *N. defodiens.* The author explained the effect of temperature on competition by different minimal temperature to fly in competing burying beetle species. Probably, typical forest species, such as *N. vespilloides*, have a lower minimal temperature to fly than species preferring warmer habitats, such as meadows. In the forest edge we observed similar thermal conditions as in forest, and probably for this reason individuals of *N. vespilloides* might be winning the competition in the forest edge. A similar relationship was observed between two species of ground beetles (Coleoptera, Carabidae): *Pterostichus melanarius* Illiger and *Poecilus versicolor* Sturm. The former species was more active in warmer temperatures (Lang *et al.,* 2012). Like *N. orbicollis,* also *P. melanarius* was characterized by larger body size than the competitor. Therefore, Lang *et al*. (2012) suggested that the higher activity of larger species in warmer temperature may be also associated with different sensitivity to warming of metabolic rates of both species. However, due to phenomenon of carcass take over, in case of burying beetles, numerous presences may not be the determinant of competition success.

Individuals of both species in different way colonized resources placed at the studies area and these differences were also observed in forest edge. However, our results about day of carcasses colonization were similar to results obtained by Trumbo (1990b), which showed that burying beetles preferred older carcasses than fresh. The results of research conducted by von von Hoermann *et al.* (2013) with Kramer sphere, suggested that activity of *N. vespilloides* should be gradually increase in each subsequent day of carcass exposition. However, in our observation the highest activity of individuals of this species were noted in second day of research series, but in following day, activity is maintained at a slightly lower level. This difference probably is a result of differences between laboratory observation and research conducted in natural conditions. In addition, activity in response on olfactory stimulus does not necessarily imply an ability of burying beetles to carcass find and colonization.

Results of our analysis of daily activity of burying beetles confirm the outcome of previous research conducted by Kocarek (2001). *N. vespilloides* was observed throughout the day, but its activity peaked at 8 pm. The highest activity of *N. vespillo* individuals was observed in the afternoon. However, daily activity in forest edge was very similar to daily activity observed in other types of habitat.

Beside environmental conditions and dispersal ability, population size and density also have a strong influence on competition between species (Kuriwada *et al.,* 2013; Trumbo *et al.,* 2000). Adult individuals of *N. vespillo* during research were observed less frequently than *N. vespilloides*. This could contribute to the lower abundance of *N. vespillo* on the edge of two habitats. Previous studies about population density of burying beetles show that populations of species that prefer open areas are very sensitive to habitat fragmentation (Trumbo *et al.,* 2000). Habitat fragmentation generates many edges, which reduces the minimal size of populations and their density. A good example of this relationship is a study of competition between American species of burying beetles, where typical forest species dominated but

population density of species preferring open habitats was correlated with: habitat size. Environmental conditions and seasonal activity did not affect population size (Trumbo *et al.,* 2000). However, in the cited authors did not observe any burying beetle species on the edge of meadow and forest.

In summary, this is the first report on differences in activity of burying beetle species on the forest edge. Results of this preliminary study indicate that individuals of *N. vespilloides* outcompeted *N. vespillo* in the forest edge. However, this hypothesis must be confirmed by further research, because usurpation of resources by other burying beetles was sometimes observed. It is possible that carcasses found by *N. vespilloides* were later taken over by the bigger and stronger individuals of *N. vespillo*. Furthermore, the presented results could also be affected by the small number of *N. vespillo* noted during the study. Therefore research on burying beetle competition will be continued in the future, with more cages. In addition, we will check their reproduction success and probability of resource usurpation by other burying beetle species.

ACKNOWLEDGMENT

AU is support by scholarship under the Operational Program Human Capitol, European Social Fund.

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Received: March 12, 2014 *Accepted: April 02, 2015*